NAIP 2005

California, Montana, Texas

Leica ADS40

Project team:

- ► Team comprised of 3 companies (North West, EarthData, Horizons)
- ► 5 Cessna Conquest propjet aircraft
- ► 2 Learjets (Leased)
- ► 7 ADS40 sensors
  - All with FCIR "fix"

Flight layout

► The ADS40 acquires a "pixel carpet" as we fly:

- Forward overlap is not a concern as it is always 100%

- We adjust flying height to capture 0.8m data for 1m states, and 1.3m (altitude limited) for 2m states

- This represents anywhere from a 25% - 100% savings in flight time

- RVSM is required for 1m states, for 2m we are above RVSM airspace

- Turn around time is critical for NAIP – eliminating flight time is the first step to shortening the delivery time and reducing cost

California data acquisition:

► Due to RVSM approval delays California was flown under the RVSM airspace

► This resulted in an additional 33% flight line miles, and corresponding 33% additional processing

► During good weather up to 5 aircraft operating

► May 29 – July 3, August 13 – September 29
  - Due to contract delays many county priorities could not be met
  - Late snow was a problem causing a 1 month break in acquisition in the high ground
  - 87 flights to capture entire state
  - 10.7Tb of raw sensor data

California data processing:

► Many DEM issues encountered

► Most attributed to aggressive land development

► Over 100 areas where DEM "clean up" was required

► Due to late snow delayed completion of many CCM's due to lack of complete coverage

► Sample CCM's provided and approved

► Specification "creep" is an issue
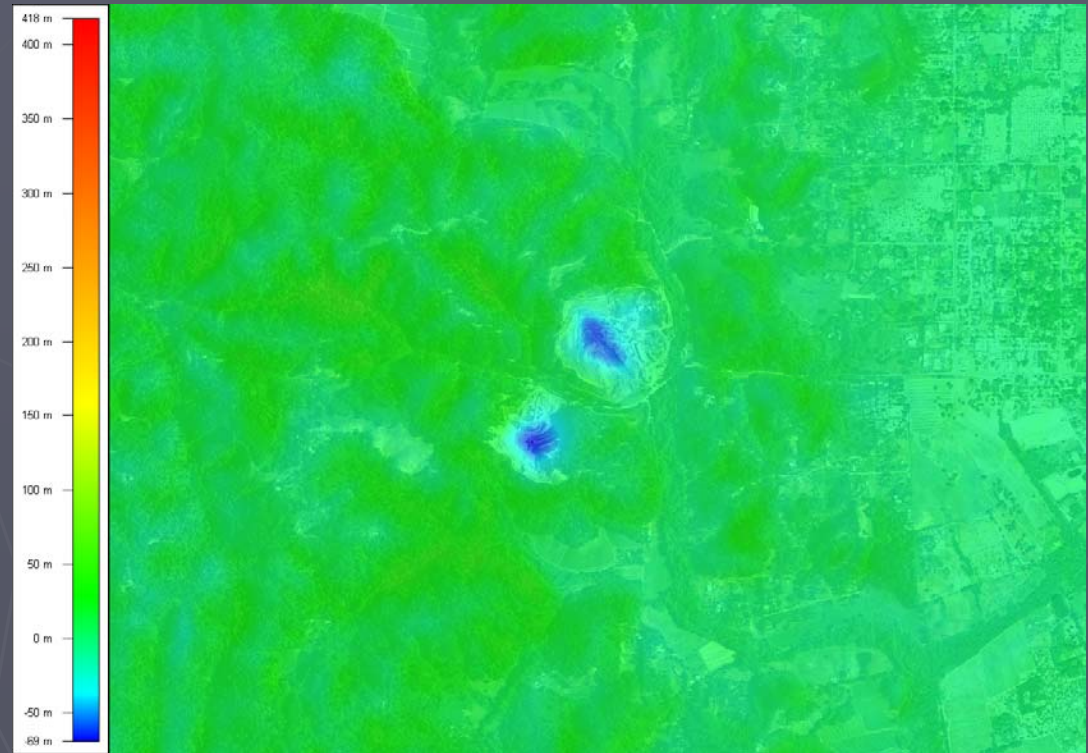
Montana data acquisition:

► Due to RVSM approval delays Montana was also flown under the RVSM airspace

► This resulted in an additional 50% flight line miles, and corresponding 50% additional processing volume

► During good weather 5 aircraft operating

► July 1 – Sept 20 window

- Slow start due to late snow melt

- 81 total flights to capture state

- 8.1Tb raw sensor data collected

Montana data processing:

► DEM much less of an issue, but some problem areas

► Extreme subject matter variations made radiometric correction a challenge

► Compromise between seamless county and preserving detail in fields a issue

► Large and irregular shaped counties made CCM completion a challenge

► Sample CCM's provided and client appears to be pleased

  ▪ "No news is good news?"

Texas data acquisition:

- ► Texas data acquisition was difficult due to poor weather
- ► June 28 – Oct 22
  - 88 flights to capture state
  - 6.2Tb raw sensor data
- ► Lear Jet's did prove very efficient – 4 DOQQ's per minute when online
- ► Record of 1652 DOQQ's collected in one day by one aircraft – 9% of Texas
- ► Due to contract delays many county priorities could not be met

Texas data processing:

- ► Texas was the first project to utilize NWG's new AT process for the ADS40
- ► Utilizes the benefits of the ADS technology, opposed to fitting into a frame workflow:
  - ▪ Similar to satellite image processing
  - ▪ Complexity is to model a much more turbulent environment
- ► Block of 1000 DOQQ's (Texas) from raw data to ortho strips:
  - ▪ Leica GPRO: POSPac/L1/APM/ORIMA/Control/Bundle/L2
    - ► Computer time: ~28 hours on 10 node/40 CPU cluster
    - ► *Human time: 6-12 hours*
  - ▪ NWG: APM/Control/Bundle/L2
    - ► Computer time: ~50 minutes 10 node/40 CPU cluster
    - ► *Human time: 40 minutes*
- ► More important is the ability to *keep up and progressively deliver with* the acquisition:
  - ▪ No limit on line length
  - ▪ No limit on block sizes
  - ▪ Very easy to patch in reflights
- ► Big impact for NAIP – much faster delivery!
  - ▪ Under 2 weeks from acquisition to completed ready to ship DOQQ's
  - ▪ CCM's ~2 days later depending on complete county coverage
- ► North Dakota also processed with this process
- ► Full technical details of this new approach will be presented at ASPRS 2006 in Reno
- ► First step in the "lights out pixel factory"

"Super resolution"

► Super resolution technology is a 'hot' research field

► Concept is to take 2 or more low resolution images and using advanced signal processing techniques combine them into a much higher resolution image

► Final resolution is difficult to quantify, opinions vary from 1.5X – 4X the input images
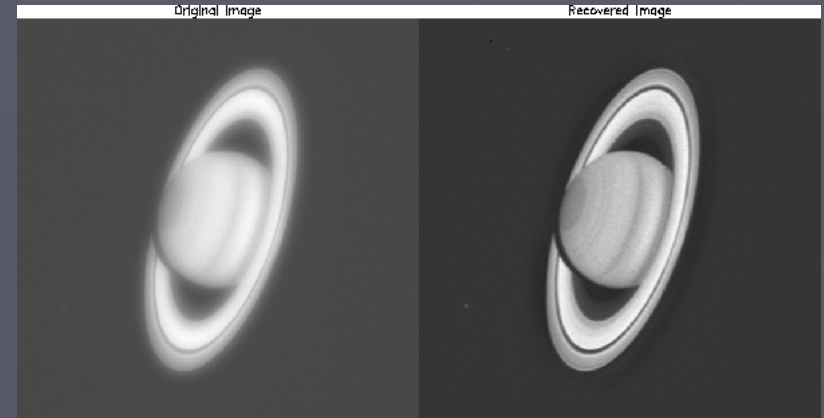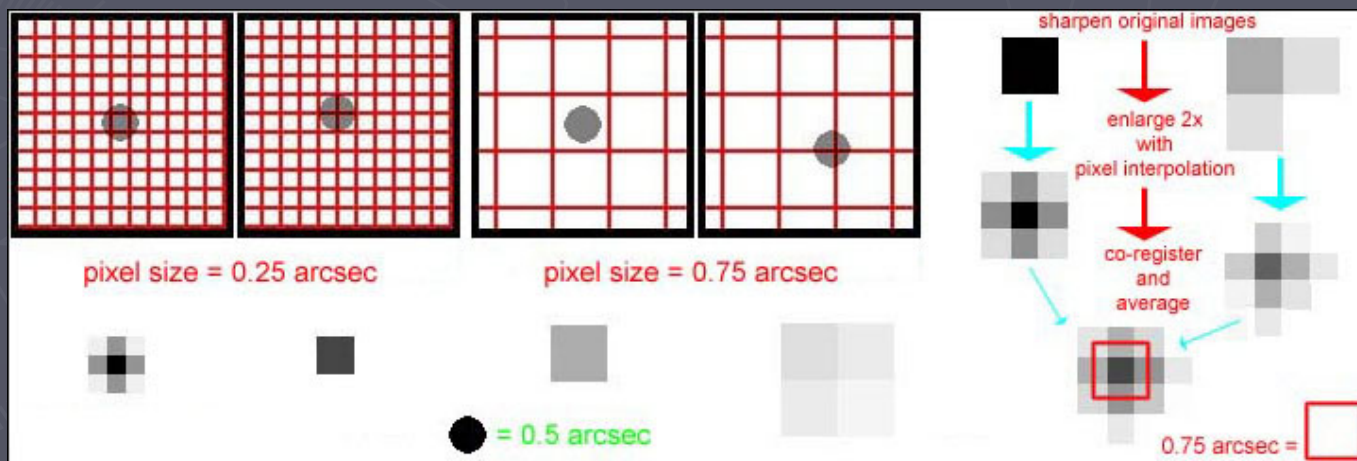

Figure 5.   Sample recovery of an HST image of Saturn.

Super resolution and the ADS40?

- ▶ ADS40 has staggered pan arrays of 12,000 pixels offset by ½ pixel
- ▶ Also ability to run these pan lines at twice the read-out rate as the spectral bands
- ▶ This is possible as pan lines have much better signal to noise ratio than spectral bands due to lack of filters and beam splitter device
- ▶ These 2 pan images perfectly fit the requirement for the super resolution algorithm as they are offset ½ pixel from each other, have overlapping pixel content, and have very similar radiometric characteristics
- ▶ What happens if we apply super resolution processing to these 2 panchromatic images, and pan sharpen?

sharpen original images

enlarge 2x with pixel interpolation

co-register and average

pixel size = 0.25 arcsec

pixel size = 0.75 arcsec

● = 0.5 arcsec

0.75 arcsec =

1 foot resolution from 28,000 feet?

► 0.90m spectral GSD

► 0.90m panchromatic GSD

► Theoretical 0.30m pan GSD after super resolution processing

► Pan sharpened 2:1 ratio (4 pan to 1 spectral pixel)

► Drawbacks:
  ▪ About 6 hours per DOQQ to apply algorithm!
  ▪ Sharp edges show some fringing due to pan sharpening
  ▪ "Perfect" DSM required

► Benefits:
  ▪ 3 DOQQ's/minute acquisition
  ▪ Less human processing time due to fewer image strips for a given area
  ▪ Works with color or FCIR

Super resolution and ADS40

Super resolution and ADS40

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Radiometric corrections

► Typically we collect ~700 gray values in the spectral bands and ~1400 in the panchromatic bands with ADS40

► Challenge is to map this down to 8 bit (255 values) without loosing the detail FSA requires

► Tools Leica provides are very poor

  ▪ Had to write our own

► Crop lands are typically quite monotone:

  ▪ Let buildings and urban area blow out to preserve more crop detail?

  ▪ Preserve top end of histogram and loose crop detail?

► The best product for interpretation is generally not the most visually pleasing!

  ▪ this is often in conflict with other funding partners

► Perhaps the solution is a split delivery:

  ▪ Fast delivery full bit depth imagery for FSA crop interpretation

    ► Perhaps even "4 band" stack for additional functionality?

  ▪ Slower delivery of 8 bit "Pretty" orthos for funding partners and GIS base layer

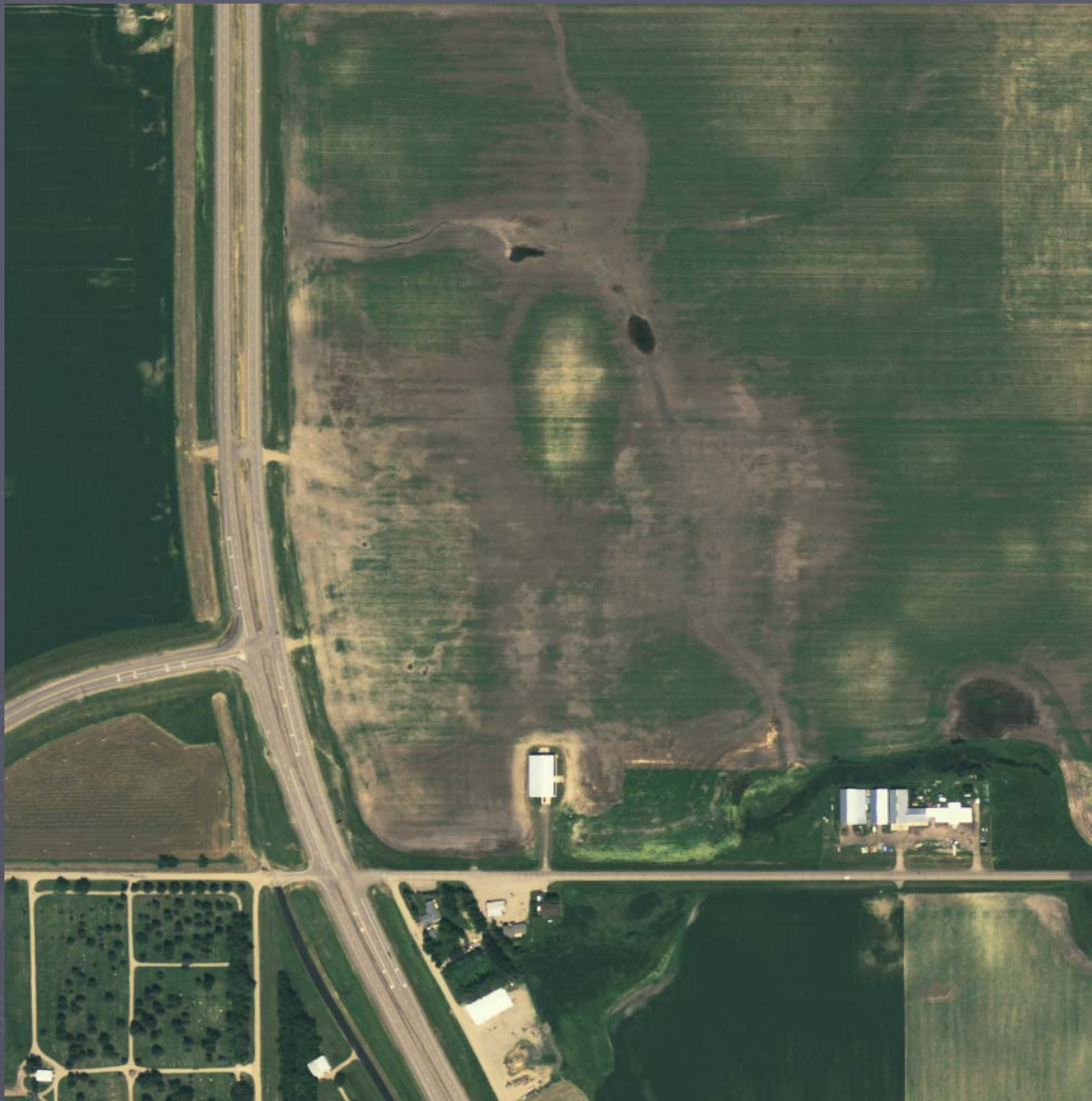 ▪ Slightly more costly, but helps to meet both program goals

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Additional sales opportunities:
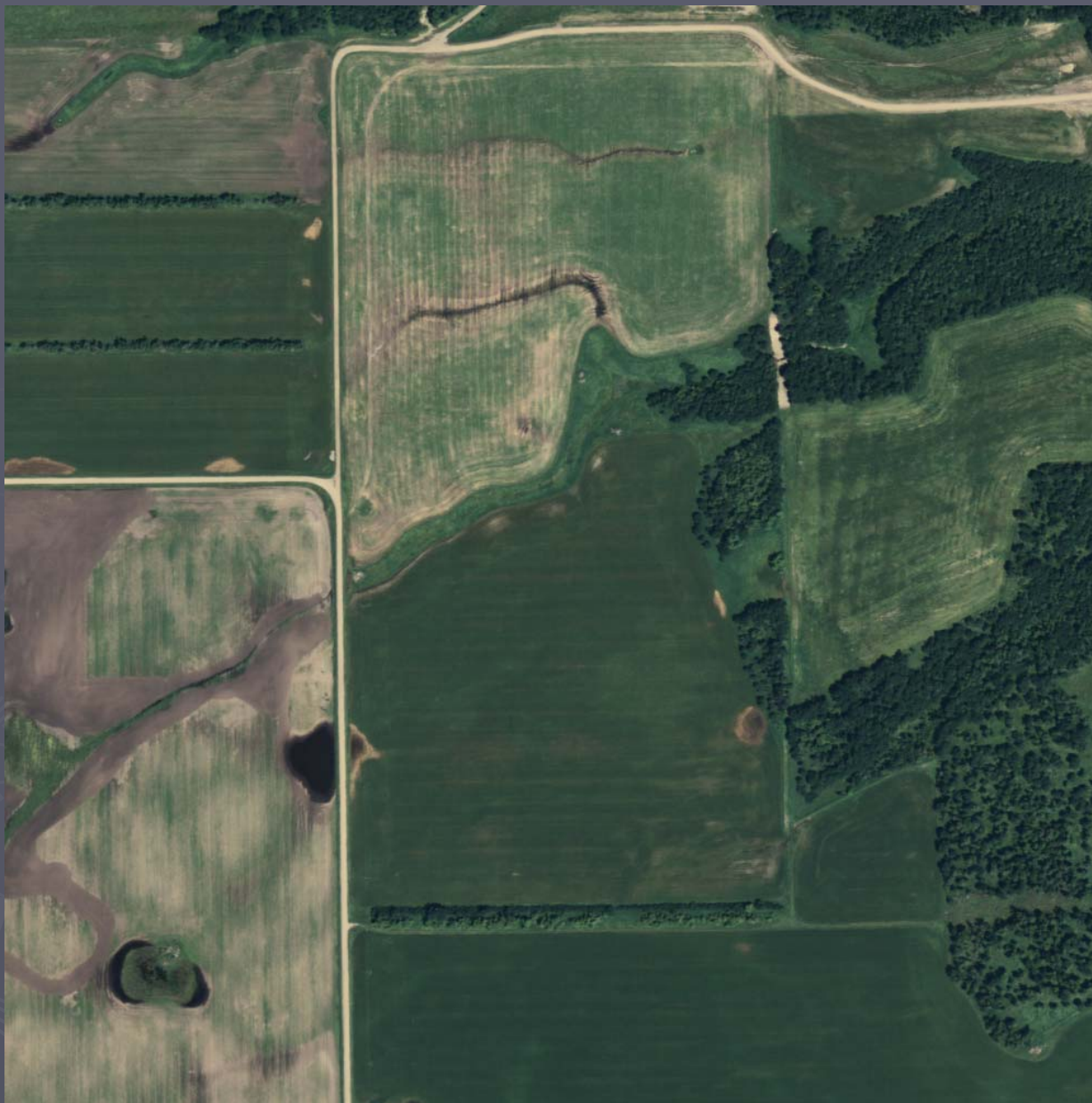
► Montana to be processed to a FCIR product for the state

► California flight area extended to acquire Mexico border area

► 120 TX DOQQ's reprocessed for absolute accuracy for NOAA

► Many other small sales for environmental uses
  ▪ Raw full bit depth orthos are the most desirable product for this purpose

► ND, MT, WY @ 1m very desirous for a large oil and gas partner of our sister company Valtus Imagery Services
  ▪ For this sale the delivery mechanism is the value, not the imagery

► Our biggest competitor in this market is the USDA itself!
  ▪ For the very low prices NAIP imagery can be bought many customers are willing to use it versus paying much more to get a customized product

Program Improvements?

► Other possible delivery formats?

- Compressed DOQQ delivery opposed to CCM's would speed up product delivery
- FTP/Web or some other type of rapid delivery
- JPEG-2K preferred over MG3

► Better clarification on flight windows/priorities

- Return to contractual fixed acquisition windows versus priority areas probably a good solution

► Some reporting mechanism for areas with poor DEM to allow future updates

Our plans for next year:

► More capacity:
  ▪ Digital Aerial Solutions has joined our team
  ▪ Capacity is now 6 Conquest and 3 Lear-Jets exclusive to NAIP
  ▪ 11 ADS40 sensors internal to team

► RVSM approval for Conquests is completed

► 2 week delivery cycle on DOQQ's, 2.5 weeks on CCM's from _flight date_

► Work with USDA on creative approaches to get data to end users faster

► Focus on alternative products possible with the ADS40 to find other sale opportunities
  ▪ 4 band imagery is a hot prospect

► Further quantification on what exactly super-resolution can gain us
  ▪ Definitely higher resolution at any given flight height, but how much?

Capacity?

► Industry has shown the ability to respond to increasing challenges:
- NHAPP
- NAPP
- NAIP
- DHS "1ft" states
- ?????

► Acquisition capacity can be increased:
- Buy more planes and sensors
- Fly "smarter"

► Digital sensors only part of the solution:
- Time to process film/scan is not the bottleneck
- Sensor type dictates processing approach

► The problem is processing capacity:
- Adding more acquisition capacity will just create bigger backlogs
- Legacy workflows are not the solution
- Innovation needed to address the processing bottleneck
- NAIP allows this

► Set the bar high, give industry 2 years to achieve it
- Our internal goal – 24 hours from acquisition to web available product

Questions?

► Thank you to the USDA-FSA allowing us the opportunity to be part of this challenging program.

► Any questions?

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